

Epidemiology of cyanobacteria and their toxins

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Introduction

Epidemiology is partly defined as the study of the distribution and determinants of health-related states or events in specified populations (Last 2001). In this context, "study" includes observation, hypothesis testing, analytic research, and experiments. In turn, each of these approaches provides results with differing strengths of evidence linking human exposure and health outcome. The National Health and Medical Research Council (NHMRC) in Australia, has developed a classification for these study designs based on rigor and the minimisation of bias. The NHMRC's new pilot classification allows for studies about aetiology, where evidence extends from the strongest Level I (a systematic review of prospective cohort studies) to Level IV (case series and cross-sectional studies).

Cyanobacteria-health research in humans provides various levels of evidence.

Case series (Level IV evidence)

Gastroenteritis was reported in Charlestown West Virginia, and in towns along the Ohio River after a period of low rainfall and increased bloom formation (Veldee 1931; Tisdale 1931). In 1959 *Microcystis* spp and *Anabaena circinalis* were identified in stools of a doctor, ill after lake exposure in Canada (Dillenberg 1960). *Anabaena* and *Microcystis* blooms were found in a reservoir that supplied drinking water to a community in Brazil in 1988. Two thousand people developed gastroenteritis leading to 88 deaths (Teixeira 1993). A British Medical Journal report described two severe pneumonia deaths and 16 cases of gastrointestinal symptoms in health military recruits after canoe training on water containing a bloom of *Microcystis aeruginosa* (Turner 1990). On Palm Island just off north-east Australia, an outbreak of gastroenteritis, some with liver damage, affecting about 140 people occurred after copper sulphate was used to remove an algal bloom from a drinking water reservoir (Byth 1980). Cylindrospermopsin was likely to be responsible. The neurotoxic nonprotein amino acid beta-methylamino-L-alanine has been found in brain tissues of Alzheimer patients in Canada (Cox 2003).

Cross-sectional studies (Level IV evidence)

In Armidale, Australia, significantly increased levels of the liver enzyme gamma glutamyl transferase were found in blood samples from a pathology laboratory servicing a population of people supplied with a drinking water source from a dam containing a bloom of *Microcystis* and treated with copper sulphate (Falconer 1983). The findings from a study of water sources supported the hypothesis that microcystin in the drinking water of ponds/ditches and rivers, as opposed to deep well water, was one of the risk factors for the high incidence of primary liver cancer in China (Ueno 1996).

Retrospective case-control study (Level III-3 evidence)

Along 8 Murray River towns in Australia, the risk of gastrointestinal symptoms was significantly associated with drinking chlorinated river water during a period of raised cyanobacterial cell counts compared to rain water, and the risk of gastrointestinal and skin symptoms was associated with using untreated river water rather than rain water for domestic purposes (el Saadi, 1995).

Prospective cohort study (Level II evidence)

Following recreational bloom exposure in lakes in South-Eastern Australia, symptom occurrence was significantly associated with duration of water contact, and with cyanobacterial cell density. *Microcystis* spp, *Anabaena* spp, *Aphanizomenon* spp and *Nodularia* spp, some toxic, were identified (Pilotto 1997). One hundred and sixteen (89%) patients at a dialysis centre in Brazil who received a likely untreated water supply became ill (50 died from acute liver failure) compared to no illness at a nearby dialysis centre that received treated water. Microcystins were found in the water reservoir, and in the serum and liver tissue of ill patients (Jochimsen 1998).

Randomised controlled trial (RCT) (Level II evidence)

Using a double-blind approach to skin-patch testing for 6 cyanobacterial species, on average, approximately 20% of individuals reacted across the concentration ranges tested. The reaction was mild, and in all cases was resolved without treatment. No dose-response was found (Pilotto 2004).

Conclusion

Clearly cyanobacteria (toxins) are linked to adverse health effects in healthy people. Routes of exposure are through ingestion, inhalation and surface exposure. Unfortunately most of the research related to the health effects of cyanobacterial (toxin) exposure provides lower levels of evidence, which contribute little to the development of safety guidelines. Current Level II studies provide limited helpful exposure level information. Clearly the adverse effects of such toxins severely restrict their use in experimental (RCT) studies in humans.